THE UNITY OF MATTER:

BEING THOUGHTS ON THE

Nature, Weight, & Expansion of Gases.

BY

G. T. CARRUTHERS, M. A.

1883

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THE UNITY OF MATTER.

Chemists have discovered a large number of substances which they call elementary, because they cannot reduce them to a more simple form.

Hence we are led to the contemplation of the nature of matter. If matter is eternal, which I cannot believe, are we to suppose that there are 60 or 70 of these eternal things?

If there is a Creator of matter, are we to suppose that He called into being, one by one, all these elementary forms, and some of them in such minute proportion to the immense masses of others that the reason of their existence becomes as great a mystery as their creation?

The Alchemists supposed that there was a simple substance underlying all the outward forms of matter which had no inherent attributes except those of extension and density; and, being persuaded of this, they devoted all their energies to discover in what way Nature transmuted the baser metals into the precious metals—gold and silver.

They failed to make the discovery, and deservedly so, for we never read that the converse was sought after—by which gold might be turned into earth and stone! nor did they attempt to learn by what process Nature took the deep things of the earth and gradually changed them into the familiar but grosser objects on the earth's surface. This knowledge was only arrived at when the thirst for gold had passed away and men loved knowledge for its own sake.

Moderns have, however, accepted the dogma that all matter has one non-essential characteristic, inherent in, and common to, every elementary form of matter—namely, that of being able to attract other matter; and, believing this, they find no difficulty in accepting the idea that there are 60 or 70 primitive forms, each having additional inherent nd mar-

vellous properties of its own. It is, indeed, a mere accident that the property of being able to jump over a five-barred gate belongs to a compound of elementary forms instead of to a simple form of matter.

Those who will not accept the notion of the unity of matter because it is not supported by experiment, and yet find it difficult to account for the presence of so many elementary forms on the one earth may perhaps think as follows:

There are 60 or 70 centres of creation or centres of matter in the universe. The vapours issuing from these fill space and so interpenetrate one another that the planets appropriate and condense proportions of them all as they proceed in their orbits.

Thus the earth, the abode of oxygen, steals its nitrogen from Mars which is ruddy with its nitric-peroxide, Venus shines bright with its inherent carbon and the earth's oxygen, while the Sun is the great source of hydrogen.

This view however would only remove one step farther off the difficulty of accounting for the existence of so many forms of matter having inherent attributes beyond the simple one of extension in space.

In recent years an attempt has been made to deduce all matter from one of the elements, and Sir John Herschel, in a joking way, in opposition to mere enthusiasts, proposed that electricity should be introduced as the great moving force which is to change hydrogen into all things.

Chemists have, however, tried so assiduously to break up the elements into others, and to change their form, or to deduce simple elements from other simple elements that it seems to be utterly improbable that any such change can be brought about by any means at present in their power.

Now when men in a wood have lost their way it some times happens that the best way to find their way out is to keep straight on, but at other times it is wiser to try different roads till at last some familiar objects in one of the roads catch their eye, which assure them that the right road is in that direction; so also it may be in the pursuit of chemistry.

It may be right to keep blundering on trying to simplify that which is already simple, but it may be wiser to try to arrive at the unity of matter by some other process.

Let us then, leaving the simple forms, take one of the so called compound forms of matter, and, instead of splitting it up into its elements, try rather to raise upon it all other elements.

Let us for instance take water. We know that if we place in water the terminals of a battery, two so called simple substances will issue from it; now why may not these be only other forms of watery matter?

It is possible that they may each contain exactly the same constituents as water but have different properties because they contain the watery constituents in widely different proportions.

Let us suppose that water is formed of some vapour and some absorbing solid in such a way that the fall of a solid atom, caused by its absorption of the surrounding vapour, would create a heat sufficient to evaporate the amount of vapour absorbed by it; and let watery vapour be the separation of solid particles from the mass under the influence of greater heat by the pouring forth of molecules of matter from their spherical surfaces.

In the formation of gases from water, the sudden internal heat and commotion caused by the introduction of the poles of a battery may be supposed to cause the solid particles to be hurled together before the vapour issuing from their inner surfaces could escape, so that hollow metal spheres containing vapour would be formed while the outer surfaces would be quite desiccated. In water the very first movement of heat produces vapour so that the spheres will have vapour at the tension of freezing point.

A true gas may hence be supposed to be formed when the tension of the vapour within the solid is met by the solid's pressure; and the volume of the gas at freezing point is such that when the vapour within condenses, and the solid falls, it produces heat sufficient to evaporate the vapour again to

its former tension at freezing point. The weight of the gas will be made up of the confined vapour, together with the weight of solid which keeps the *vapour* at its maximum density for the temperature which it had when it was inclosed.

Watery vapour at freezing point has a tension of about 12. 27 ℔s to the square foot, and at its point of saturation, a pound of it occupies 3390 cubic feet.

It is known also that water contains 2 parts by volume of hydrogen and one of oxygen, we may therefore suppose that two-thirds of 3390 is the volume of hydrogen. The pressure upon these 2260 feet is, I suppose, the same as in watery vapour, for the heat is not diminished and the oxygen only swells each little hydrogen volume as a balloon in a chamber of compressed air occupies room. This appears probable since the hydrogen alone can be withdrawn, or the oxygen, which could not occur if the gases were mixed unless by the use of some magnetic sorter which would have power over the gases like a magnet over iron filings; and even then there would require to be two sorters; but we have no evidence that the poles of a battery are magnets to either oxygen or hydrogen when they have once got out of the water. The gas, if formed under these conditions, would, from our definition of a gas, have a density of 12·27 ℔s., together with one-ninth of a pound, due to the weight of the vapour, divided by 2260 the volume occupied. This would give a density of ·0055 ℔s. per cubic foot, which approaches to the density of hydrogen which is ·0056

Saturated watery vapour differs from watery vapour by the fact of its being confined in a chamber and by the form given to its vapour which is contained, in a saturated state, in little water vesicles and no longer radiates from a central solid. If we chose to call the compressing chamber a part of the mixture then in that condition it would be a gas, for we should have the solid and the vapour. The vapour in a gas need not be derived from the sides of the volume but from an evaporating liquid in the centre. Thus, saturated water vapour has the barren sides of the chamber, and perhaps

barren central floating spheres of oxygen, besides the mother liquid which evaporates and condenses the vapour according to circumstances of pressure and temperature.

I have deduced the volume and weight of a pound of hydrogen from another consideration which in some respects is more satisfactory than that just now given.

By the law of gravity a solid pound falling 16 feet would rise to the same height again; but if it were of the density of a pound to a foot, and were to burst and diffuse itself, in rising, into a vertical chamber of a foot square it would do no more work if it were to occupy 32 feet of the chamber.

Taking note of this, we proceed.

In steam at 212° the volume of a pound is 26·36 cubic feet and the tension is 2116·4 ℔s. on the square foot. We need not consider the pressure on the sides of the chamber, for these are supposed to be sustained by the parabolic curves of the atoms, each travelling with its terminal velocity in the medium and with a velocity at the vertex in the ratio of its initial velocity. Such a velocity as would necessarily be obtained if the force was directly as the atom's surface and inversely as its weight.

The tension, then, is made up of a pressure keeping 2116·4 ℔s. from falling and of a play of particles through the 26·36 cubic feet.

This play of particles is due entirely to their height of fall, for it is found that a reduction of the volume requires no additional pressure to be applied to the piston but that the particles drop down into water when the density is disturbed.

This may perhaps be explained thus: Let the steam consist of but one particle of a pound weight, then it has a momentum of 1×41 to carry it up 26·36 feet and a momentum there of $2116{\cdot}4 \times 32$ ℔s. to resist the fall of the piston.

Let now the volume of the chamber be reduced to 16 feet, the pound would then indeed attempt to rise 26·36 feet, but as 32 feet velocity would be lost in rising 16 feet, the extent to which it could then move the piston upwards, would only

be the result of a momentum of 41 — 32 = 9 lbs. in addition to 2116·4 × 32 lbs. which of course is a mere nothing; the piston therefore would remain at 16 feet and the 1 pound of steam would fall into the mother liquid with an acquired velocity of 32 feet.

But though it would rise out of the water again, it would not rise in a fit state to acquire the necessary vibrations from the vibrating force of heat, for the particles of steam which are duly disposed for vibrations are saturated particles which are so formed that a thrust in addition to the pressing weight would send their contained vapour into the state of water, and heat applied to the water within would expand the atom again to its former size. The 1 lb. particle therefore being originally in equilibrium for a momentum of 41 feet would simply crush in the vapour within it which had received only 32 feet momentum by the last fall, and there would be no vibration; so that though an enormous force is acting, the particle remains, like the mother liquid, quiescent because not in the condition to vibrate. If, however, a new formation takes place in the water, or if we liken the particle to a bubble loaded, then on a portion of the load being dropped we may suppose $\frac{3}{4}$ of the lb. to be now in a condition to receive vibrational thrusts sufficient to give a momentum that will carry it the due height, and then give a blow upwards of 2116 × 32 against the falling piston. In this way the density of the steam would remain constant under the reduction of volume even to the end.

The play of the particles in 26·36. feet being due simply to the height of their fall, and the rise and fall being that of vapour, a solid lb of the same material would be kept in equilibrium by its rise and fall through half the height of 26·36 cubic feet of diffused vapour.

But, as a gas contains its pressing solid, the above would be the volume of a gas containing 2116·4 lbs. of solid at the same temperature of 212°.

But by Boyle's Law the volume is inversely as the

pressure therefore at freezing point with a pressure of 12·27 lbs. the volume would be—

$$\text{As } 12{\cdot}27 : 2116{\cdot}4 : : \frac{26{\cdot}36}{2} = 2273{\cdot}3 \text{ cubic feet.}$$

The density of a cubic foot would thus be composed of half a lb. vapour, for only half the volume is used and the 12·27 lbs. solid, divided by 2273·3 = ·00562 lbs.

The density of hydrogen is ·0056 lbs. per cubic foot. The poles of a battery are not equal in heating power, and it is found that oxygen escapes from the hotter of the two when both poles are placed in water.

Now in the case of saturated vapour there is a decreased volume as the temperature rises, and the weight of the piston required to preserve equilibrium must be increased in due proportion.

But the quantity of steam produced must depend upon the speedy reduction in size of the previous atom which filled the containing chamber, it therefore depends upon the velocity acquired by the fall of the atoms in the volume. Therefore, a substance having a vertical volume one quarter that of hydrogen would have half the velocity, or while hydrogen was issuing from the water to become one volume, the lesser but denser and hotter substance would become half a volume. But steam of volume one-fourth that at freezing point requires a pressure of about 48 lbs., and we have taken it for granted that the vapour we are dealing with is similar in nature if not the same. But a gas includes its pressing solid in its volume, therefore while hydrogen is arranging its 12 lbs. in its one volume, oxygen is arranging itself in two quarter volumes of 48 lbs. each, or while the one volume of hydrogen is one atom that of the oxygen is made up of 2 atoms occupying half a volume of hydrogen and weighing 8.

The densities of the gases will thus be as 1 to 16 in the quiescent state.

To fix our notions of what has been said we may conceive that hydrogen has one volume, requiring for the saturation of its vapour a pressure 1, and therefore (neglecting

the weight of its vapour, which would only have a density of $\frac{1}{3390} \times \frac{1}{12 \cdot 27}$ lbs. to a foot) being of weight 1.

Oxygen has 4 spheres contained in volume 1 with pressure of each 4, and therefore of total weight 16. Watery vapour contains one volume of oxygen and two of hydrogen made up of 4 small and 2 large spheres with total weight 18.

When these combine to form water gas, the vapour assumes in each sphere the tension of hydrogen, and is then reduced by pressure of 3 on each sphere, or 18 in all, to one-third its volume. There are thus six spheres bound together, each of one-third a volume, and therefore of pressure 3 or weight 3 and total volume 2. This double volume is called a molecule, and it is quite obvious that whatever weight of the separate gases is taken in the proportion $O\ H_2$ the issue must be in molecules. The mystery of molecular changes therefore simply depends upon spheres not being ready to burst. A volume of the gas of course weighs only 9.

When the gases commingle in any proportions it is probable that the first step is to reduce the gases to a vibrational form, and that the action takes place sphere by sphere. Thus a sphere of oxygen, weight 4, reduces one of hydrogen to $\frac{1}{4}$ its size, so that the density is similar but the pressure is now only 1 to 4; a second oxygen sphere reduces another hydrogen sphere with the same result. If now a third and fourth sphere of oxygen simply rest upon the lower spheres, these have density 4 and pressuro 4, and the former two also have the same, they are therefore put in a position to receive the necessary vibration of 1 to 8 from the spark of the battery, and water is formed. Thero being no more oxygen in the mixture, the rest of tho hydrogen remains unchanged.

The reason for the gas's immediate collapse into the state of water is that we havo 1 pound occupying one-third of 3390 feet under a pressure of about 42 lbs. instead of 12 and which demands about 60° of heat. When the gas therefore impinges upon the side of a colder vessel, or even of a vessel

equally cold, but with a greater power of absorbing heat in the same time, the energy of the impact compresses the sphere and developes some of its heat, but it is taken away by the colder vessel as soon as it is produced; but the gas is saturated vapour under a pressure of 12·27 lbs., therefore when the heat leaves it, it cannot support the 42 lbs. and the sphere falls in upon the vapour, which decreases, and must become water unless some part of the 42 lbs. is removed. It cannot be removed, and therefore 1130 feet sink down into ·016 cubic feet, the volume of a pound of water, which is the state to which the 42 lbs. which were doing the work of own imaginary solid, had already arrived. The same thing occurs to the six spheres.

It is a peculiarity of gases that they increase by ·00366 of each volume for every degree centigrade, and if we remember that "every compound which evaporates without decomposition has a vapour density proportional to its molecular weight," we must feel the force of the conclusion that all gases are formed out of the same vapour and solid. I here give a reason for the expansion of gases by heat.

We take a quantity of vapour of such a volume that at freezing point it has a square foot, for its whole surface, and therefore a volume of ·09403 c. feet. At that temperature 1 lb. of vapour requires a pressure of 12·27 lbs. per square foot and has a volume of 3390 feet. Therefore 3390 : ·094 : : 1 lb. = ·000027738 which will give the weight occupying ·094 volume; and ·000027738 × 12·27 = ·0003402 will give the pressure on a square foot. The $\frac{1}{3390}$ of ·094 corresponds to one of the 3390 feet when 1 lb. of vapour pervades them.

In a cubic foot ·094 is contained 10·634 times, and we may take these as 10·634 spheres, each having vapour within it and kept at its maximum density by the pressure on its foot of surface. The density of the gas, which includes its pressing solid, is ·0000278 × 10·634 = ·0002497, together with the weight ·0003402 × 10·634 = ·0036175. The whole density is therefore ·003912 lbs. per cubic foot.

The pressure which the 10·63 spheres of gas give to the sides of the chamber containing them, is a separate circumstance from the pressure which an individual sphere exerts within its own limits. If they are supplied with heat of 32° from an outward source, they will require the restraint of a containing vessel which must be of sufficient strength to keep the whole vapour at its point of saturation, otherwise the heat constantly supplied would extend their volume to infinity, for what is there in heat that it should not go on doing work? At saturation the constant heat is employed in preventing the constant fall of the vapour and weight.

We may omit the consideration of that part of the vapour force which keeps suspended the 12·27 lbs. and also the fall of the 12·27 lbs., supposing these two forces to act through thesuspended vapour as through a rigid rod. There remains the 1 lb. of vapour resisting the entrance of other vapour into the volume. Now suppose the force in the water to act alternately with the force above it. Then the lb. falling could only condense 1 cubic foot of similar vapour, rising from the liquid, into $\frac{1}{3390}$ of a foot and the force in the water could necessarily only do the equivalent, so that we might conceive of two solid lbs. one in, and the other out, of the water constantly condensing and expanding between them a foot of vapour. Now we have no reason to suppose that the density of $\frac{1}{3390}$ to a foot of volume can be produced except when 12·27 lbs. are pressing, nor that the vapour previous to issue assumes the density of 1 lb. to the foot; but given that pressure, then the heat in the water can only evaporate $\frac{1}{3390}$ of a lb. in the same time that the weight above the water can condense it. Other weights, such as 2116 lbs. to the foot, have their proportionate effect and when there is the above equilibrium, in each instance there will be what is called a state of saturated vapour in which the pressure and density remain constant so long as the temperature remains the same.

The restraint of the chamber containing the gas will require to meet two forces, namely, the desire of the whole cubic foot to turn into vapour at 32° by evaporation from the surface, and the desire of the little spheres each to do the same from their 10·63 square feet of surface.

The mass ·003912 will be prevented from any further evaporation by a pressure of (3390 × ·003912 × 12·27) × 12·264 lbs = 1994·9 since it is 12·264 times denser than vapour at 32°. In saturation of vapour of that density 12·26 separate chambers would be required, as heat at 32° will only produce a certain quantity of vapour in 3390 feet from water. But here we are only dealing with the pressure of the lid of a box and the height of vapour which the mass would require if there was no lid is of no consequence. The height would be 12·26 times 3390 and the mass ·003912 would be the mother liquid ready prepared for evaporation.

The 10 spheres have vapour shut up within them and not in contact with the chamber. This vapour, whatever its density, and it is only ·000295 lbs. to a foot, will accumulate heat and expand the spheres till it reaches a point when the nascent heat is consumed. The necessary pressure would be (3390 × ·000295 × 12·27) upon each square foot. Now a foot out of the 10·63 has already been included in the square foot of the chamber, or rather about ⅔ of a foot, for if we take a material line to be a thin cylinder and then fill it with minute spheres, and keep reducing the width of the cylinder, and putting smaller and smaller spheres inside, and finally planing down the cylinder to make a flat line, each such sphere may be supposed to touch about ⅔ of it own length and breadth of the line, since it is ⅔ of the circumscribing cylinder in volume.

There will thus be a pressure of (10·63 — ·66) × (3390 × ·000295 × 12·27) = 9·967 × 12·27 = 122·5

The sum of the pressures is 1994·9 + 122·5 = 2117·4. We may now perhaps deduct 1 pound, as a pound of vapour is not required to be hurled backwards and forwards between the lid of the chamber and its contents, so that we have

remaining 2116·4 lbs., which is the pressure of the atmosphere, and is the pressure required by a normal gas at 32° to keep it saturated.

It is important to notice that with the above pressure the whole mass is in saturated equilibrium, but the volume is ready to decrease or expand on the alteration of the heat supply in the minutest degree.

Let us now increase the heat to 10°C Then we know that saturated water vapour will have its pressure and density doubled and its volume halved. The gas, by the hypothesis receives no additional pressure on the piston, hence it will become a mere vapour and will expand with the heat.

The 10·64 spheres with a free surface of 9·967 square feet accumulate heat or keep evaporating vapour till they have given off from their surfaces $9{\cdot}967 \times 12{\cdot}27 \times \frac{1}{3390}$ $= .03606$ lbs.

But the pressure on the piston set apart for the evaporation of the spheres was said to be $9{\cdot}967 \times 12{\cdot}27$ lbs., a weight sufficient to keep the above amount of vapour in the mother liquid, but the 10° of temperature has increased the tension twice, so that twice the quantity of steam is given off now at one time than when at 0°C. When the above amount of vapour is given off it presses against the piston, after it has found room for itself, and against the spheres, thus the spheres have now the pressure of the piston and also of the out lying vapour, and there is saturation at the new temperature.

The volume of the new vapour would be $\frac{3390 \times {\cdot}03606}{2}$ c. feet, but in pressing against the piston loaded with 2116·4 lbs. its density is reduced to 1 foot a pound, for this was the condition of the original equilibrium that the pressing power should keep the whole mass at that density except the vapour at 32°, which was included within the spheres. The new temperature enables the compressed vapour to raise the piston of the chamber and take up all the room it has the power to do, which is ·03606 cubic feet.

In the same way the square foot of surface of the mass lying under the piston, which gave forth ·000295 lbs. at 0° C now gives forth ·000295 × 2 at 10° C for its tension is doubled. When these have issued they will also be condensed against the chamber to the density of a pound to the foot or will occupy ·00059 c. feet.

There is now equilibrium, for the gas pressing on the square foot was kept in equilibrium previously by pressure and was only disturbed by a force which began to produce 2 volumes of steam instead of one. Two volumes being now formed, they make with any new formation a trio, two of which devote their strength to condensing and expanding the third, so that things otherwise are as they were and the extra heat is absorbed each moment. The 10 spheres keep themselves saturated by having around them a supply of vapour equal to what they can produce at 0° C and which, because of its confinement by the piston, presses back upon the spheres ever ready to expand by heat. This counteracts the effort of the extra heat to expand the spheres while the heat of 0° C is already provided for in the pressure of the piston.

Thus the gas now occupies ·00059 + ·03606 = ·03665 cubic feet beyond its original volume of 1 foot. If this is the case for 10 degrees, then for one degree and 1 foot the expansion of a gas is ·003665 c. feet.

The expansion in other gases will take place to exactly the same extent, for they are all formed of the same materials and they all have for their foundation watery vapour. Hence at 32° the amount of evaporation from a cubic foot, having a square foot of surface, can only be $\frac{1}{3390}$ lbs. when once the gas has assumed a saturated state in reference to the pressure. This state is obtained by allowing the gas to flow into its chamber which it will continue to do until the superincumbent pressure and the tension are in equilibrium.

It is worthy of notice that as the temperature increases, the expansion of the cubic foot becomes considerable, being ·366 at 100° C and therefore, though the area of the surface is

constant at a foot, yet more than 10·63 spheres can be formed within the increased volume, so that the area of evaporation is decidedly increased and the heat will be longer in arriving at its state of equilibrium; that is more vapour will be formed and the rate of expansion will thus increase with the temperature.

If the gas is admitted to its chamber when already at a high temperature and heat be then applied, the expansion will be greater for every degree than when admitted at a low temperature, because at a high temperature the vapour of saturation is denser; a sphere, for instance, of volume one is replaced by two spheres containing each half a volume, so that apart from the tension of the gases, the power of evaporation is increased from 1 to $2 \times (\frac{1}{2})^{\frac{2}{3}}$ or from about 1 to $\frac{5}{4}$, that being the increase of surface gained.

This also accounts for the fact that in saturated water vapour, the pressure increases with the temperature and at the same time the rate of increase increases with the temperature. If the spheres were to continue of the same size then double the heat would produce double the tension, but the decrease of size of the spheres increases the area of evaporation and increases therefore the weight required to be placed upon the piston for equilibrium.

We are thus led on to doubt of that wild career of atoms and molecules which Clerk Maxwell speaks of but which has never been seen, and even my own conception of parabolic curves seems to be useless except in the passage of heavenly bodies through space where I think it will be found that gravity is caused by the condensation of vapour on the surfaces of bodies, and that these are travelling with their terminal velocity in a resisting medium. The throwing of a stone up into the air makes the earth lose its termiual velocity, and the whole force which was driving each atom at its terminal velocity to the earth's centre is now as applicable to the stone's acceleration as to the earth's. I think that there is no such thing as an inherent power to attract in matter; attraction is merely condensation between two bodies and the original impulsive

force is either that the planets are travelling at the vertex of a parabola, which is ever being turned into an ellipse, or is caused by the difference in atmospheric pressure between the fore part and after part of the planet due to rotation against the ever flowing fall of particles to the Sun.

But this is a digression. We are led, I say, to doubt of all extraordinary movements in gases, and to believe that they do not take place except when there is an expansion of atoms in all directions, as when these are released from pressure. Motes float quietly in the sunbeam, even highly condensed steam is quiescent in its boiler, and so it is with gases. They press constantly, and it may be with great momentum, but they rest in peace under due pressure.

We are led also I think to see somewhat of the reason for the transmissibility of pressure in liquids. Take the case of a gas. This is made up of a number of spheres each pressing with a similar force on the square foot in all directions and in equilibrium under pressure. If we now decrease the volume by thrusting down a piston, the point of saturation of the whole gas is disturbed, but in the gas immediately under the piston a quantity of liquid has fallen out of use. This goes to increase the density of the other part of the volume, but the heat being the same as before there is an increase of volume produced there. This will not go to push up the piston again, for all vapour there is now losing energy from the loss of fall, it will therefore push against all the rest of the surface; if any part yield, then the expansion will go on there to the end, for the other parts will have become lower then those raised and therefore there will be less energy in those vertical lines. Thus the volume will recover its former capacity and will be at rest. Of course the pressure upon the piston I suppose to be small so as not to consider the case of a material alteration in the state of the gas.

In the case of liquids proper, such as water, we form much the same conception as with gases. In the vertical column, under the piston pressing down with the force of a lb., a quantity of water equal to the height fallen by the piston

passes into the other portion of the chamber. Now water like gas is made up of round particles having a surface of a square foot and these particles, though not able to expand their inner parts, yet issue vapour from their surface by radiation, and so press equally in all directions. Let the pressure issuing from the square foot of a particle be a lb., then if resolved in three directions, the pressure in any one direction will be $\sqrt{\frac{1}{3}}$ or still as 1. Supposing there are 10 particles displaced by the piston, and that these are placed in the centre of the water, then on all the surfaces of the water there will be a total pressure of 10, or in any one direction $\sqrt{\frac{10}{3}}$. If on any surface there is a part which will not yield to the pressure, it is immaterial, the other parts yield and thy will yield and yield again till the 10 inches have found room for themselves. If there are 10 little areas moveable and the pressure on each of these areas is equal, they will each, in equal intervals of time, gain their inch, and the time will be such that the greater the whole surface pressed of the liquid the greater the time of filling the 10 piston tubes; but water being incompressible, the whole will be measured by the time taken for the first piston to make a known depression. The pressing piston tube is pushed against by the water but only as a portion of the general surface, and even this portion of the general pressure is decreased by the pressure having to meet the steady flow of the 10 cubic inches into the other part of the vessel.

The mere weight of the 1 lb. on the piston has nothing to do with the result except that it produces a change of position of fluid, but the difficulty lies in explaining why when there are 3 pistons or more open, each should require 1 lb. upon it if any one piston is forced down with a force of 1 lb. Let the beginning of the forcing take place, then we may say that the force resolved in the direction of any piston without 1 lb is $\sqrt{\frac{1}{3}}$ supposing there are only 3 pistons. That piston will therefore be forced upwards, for it has no downward pressure.

Let the force in the direction of the other piston with a lb. upon it be also $\frac{1}{\sqrt{3}}$, this, however, is pressed downwards with a lb. force and $\frac{1}{\sqrt{3}}$ cannot move it upwards. But the pound weight in the forcing piston cannot compress the water itself, therefore it must go on pushing upwards the open piston and the more open pistons there are the faster will it expend its force. If all the pistons have a pound upon them then the pressing piston can do nothing.

We may give one more suggestion as to the formation of gases but will speak of but one gas. Nitrogen cannot be directly formed from water but it may nevertheless be composed of the same constituents in different proportions.

For instance in ammonia we have 3 volumes of hydrogen and one of nitrogen all condensed into two volumes. Hydrogen contains so weak a vapour within its metallic sphere that it may be compressed almost into any space. Let us suppose then that the form of ammonia is that of 3 annular rings called nitrogen, each containing one-third of a volume, and each containing one-third of its weight of its own vapour as a mother liquid, and let there be three central hydrogen spheres inserted within these, each containing one volume condensed to one-third by the surrounding nitrogen, for when of the same density and heat it will have the same tension. These three flat discs occupy two volumes.

Now since the annular rings of vapour occupy $\frac{1}{3}$ of a volume of steam at freezing point we know that a lb. of steam of that density has a tension of about 42 lbs. to hydrogen's 12 lbs. or as 3·5 to 1, and as gas includes both vapour and the pressing piston, we have 3 rings (including the central liquid) weighing 14 lbs. to hydrogen's 1 lb. and occupying equal volumes.

It is evident from the construction that hydrogen can easily be displaced from its connection with the nitrogen, for the spheres have only to be pushed out of their cavities.

Three volumes of hydrogen can be replaced by one of

nitrogen. Let this take place then the nitrogen rings swell out and become small spheres again and whatever deficiency there may have been in volume from the pressure of the hydrogen is supplied by the mother liquid within them which evaporates till the point of saturation is reached and one volume is produced. The nitrogen introduced now lies by the side of the other and contains, as the other, 3 spheres with their nucleus of mother liquid in the one volume.

Nitrogen is also known to have five values, as in chloride of ammonium, $Cl\ N\ H_4$, but this is perhaps only an apparent quality. There is no smell of ammonia in the compound, and this is a sound argument that that strongly smelling body is not in it. We should therefore conclude that in a battery, and using Mansfield's notation, it would be thus separated :—

$$\begin{array}{c} H_2 : C\ L \\ N\ H_2 : \end{array}$$

as an amide. The first portion of hydrogen added would then form the compound into

$$\begin{array}{c} H_3 : C\ L \\ N\ H_3 : \end{array}$$

but as N is formed by three spheres and a nucleus, hydrogen in 4 portions would enter the same part of the mixture, and therefore would take the same form as the nitrogen which it displaces. The whole would now form into

$$\begin{array}{c} H : C\ L \\ H.\ H_3 + H.\ H_3 : \end{array}$$

and the hydrogen would be given off.

A solid, in the usual sense of the word, may be supposed to be formed by a vapour at boiling point placed within its containing sphere of pressure. If of low boiling point, the sides may be crushed in by common atmospheric pressure and easily evaporated, but at a high boiling point, if opportunity is taken of its critical state, it may have its vapour reduced to liquid without extra pressure by the mere closing in of the solid chamber, and when cooled in this state it will be a solid until the same amount of heat is given to it again. The vapour may be of any density and the liquid may in some

cases evaporate through porous bodies. In extreme cases we should have 12·27 lbs. of solid matter which had enveloped 3390 cubic feet, and therefore was of very small density, containing only ·016 cubic feet of water in the one foot; or 2116 lbs. of matter with only 1 lb. of vapour condensed within it, and occupying only 1 foot which is a density much greater than that of gold—platinum is only ·$\frac{2}{3}$ of it. Professor Chandler Roberts has pointed out that two molten metals diffuse through one another as if they were gases.

Carbon, from its utter dryness and great absorbing power, might perhaps be thought to be the "caput mortuum" of water and solid, from which, in combination with its own or other vapour, all matter is derived. If the original matter is gaseous, then apparently there is but one vapour and the solid around it is but part of itself solidified by pressure. Hydrogen might assert its claim on the ground that it was able to bind together its spheres in unending variation of form and number, but gas is too complicated in its structure, and must have additional extraneous pressure.

Until we know more, it is well to contemplate the possibility of water being the only simple in the world and the original matter of the universe.

G. T. CARRUTHERS.

Cuttack, Nov. 15*th*, 1883.

ORISSA MISSION PRESS.—T. F. MULHOLLAND, SUPT.